Impact Based Warning System and Decision Support Activities for Winter Weather at NOAA/NWS Marquette, MI

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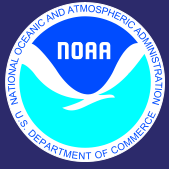**Great Lakes Operational Meteorology Workshop**
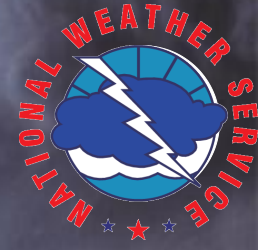
2013 May 07

Outline

- **Overview of the NWS MQT Impact Based Warning System**
  - *Background*
  - *Methodology*
  - *Results*
- **Some Decision Support Activities for Winter Weather at NWS Marquette**

# Impact Based Winter Warning System at NWS MQT

Introduction

- **National Weather Service Mission Statement**

    - *" The National Weather Service (NWS) provides weather, hydrologic, and climate forecasts and warnings for the United States, its territories, adjacent waters and ocean areas, for the <u>protection of life and property and the enhancement of the national economy</u>. NWS data and products form a national information database and infrastructure which can be used by other governmental agencies, the private sector, the public, and the global community. "*

- **The people of Upper Michigan need winter weather information that depict accurate hazards for the area. With or without headlines, winter weather affects:**

    - *Safety*

    - *Commerce*

- **"Help me help you" - Our understanding of our customer winter weather impacts further helps us help the community mitigate winter weather impacts**

Background

- In the past, all of our winter statements focused purely on the meteorology (snow/ice accumulation, etc.).

- We had little idea of what impacts really occurred during winter weather and whether our winter weather advisory/warning criteria was adequate.
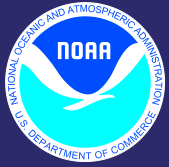
Background

- **Upper Michigan receives all "types" of snowfall with significant differences in SLR values**

  - *Lake Effect Snow*

  - *System Snow*

  - *Lake Enhanced Snow*

- **Forecasters had a sense that different types of snow related to different impacts, but it was unclear of what those were.**

Snow to Liquid Ratios (SLR) for NWS Marquette for Lake Effect, Lake Enhanced and System Snowfalls at least 1in/6hr

Solid Bar -- Median Value; Boxes 25th-75th Percentile; Whiskers 10th/90th Percentile
(x - extreme values)

LES: n=95, mean=34

Enhanced: n=84, mean=19

System: n=60, mean=14
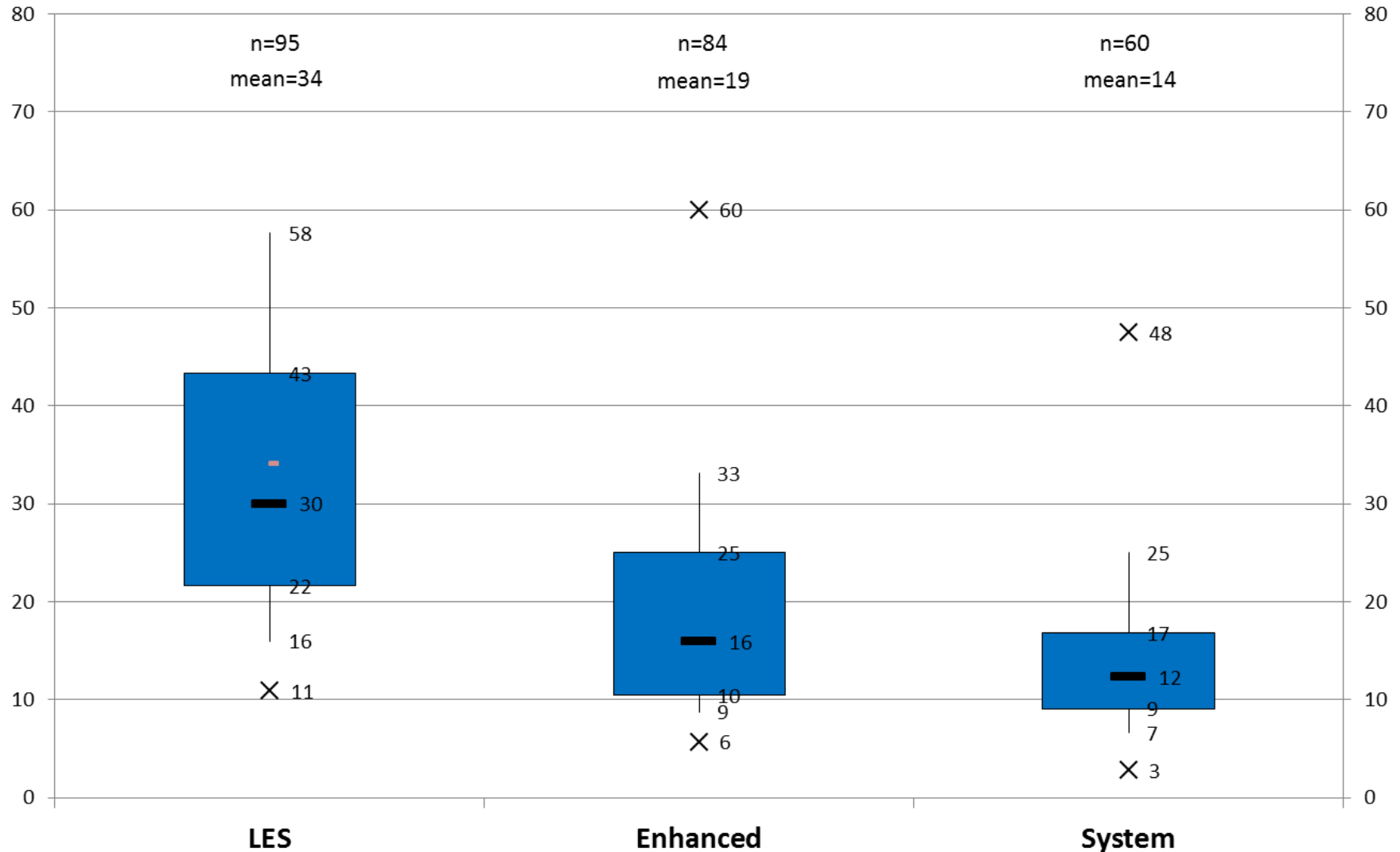
Objective

- **Better understand impacts related to Upper Michigan winter weather**

- **Refine winter weather headline issuance criteria and to account for community impacts**

- **Better communicate sociological and economic impacts in statements**
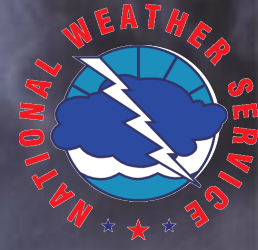
Methodology

- **Collect incident reports from 2007-2012 in Marquette County**

  - *Incident reports included Traffic Accidents/Incidents, Power Outages, Exposure*

- **Gathered meteorological data for same period:**

  - *WFO Marquette data included: Six hourly snowfall and Liquid Equivalent, Winds and Six hourly max/min temperatures*

  - *MCGM4 data included: Winds and Six hourly max/min temperatures*

- **Relate the meteorological data with incident reports**

- **Use the findings to possibly refine our winter hazard criteria and to place impact statements in our products**

Challenges and Error

- **WFO Marquette CWA features widely diverse microclimates**

  - *Higher Terrain vs. lakeshore vs. swamp*
    - **10-20°F difference between MCGM4 and WFO MQT common**
  - *Lake effect snow accumulations vary extensively*
  - *Elevation differences*

MCGM4
Elev: ~630ft

7 miles apart
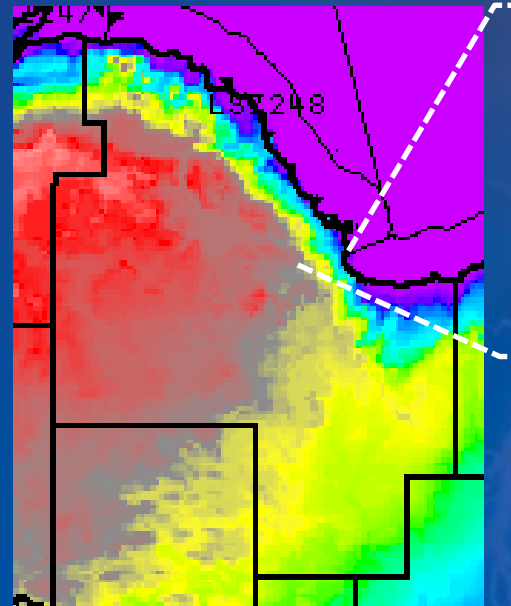
WFO MQT
Elev: ~1450ft

Challenges and Error

- **Six hourly snowfall data resolution**
  - *Spatial: Only available at WFO MQT*
  - *Temporal: Six hourly minimum*
    - **Did 6 inches of snow fall in 2 hours or 6 hours?**

2008-2009 SEASON SNOWFALL TOTALS

Legend:
- <50"
- 50-100"
- 100-150"
- 150-200"
- 200-250"
- >250"

Snow totals provided by National Weather Service cooperative observers and snow spotters
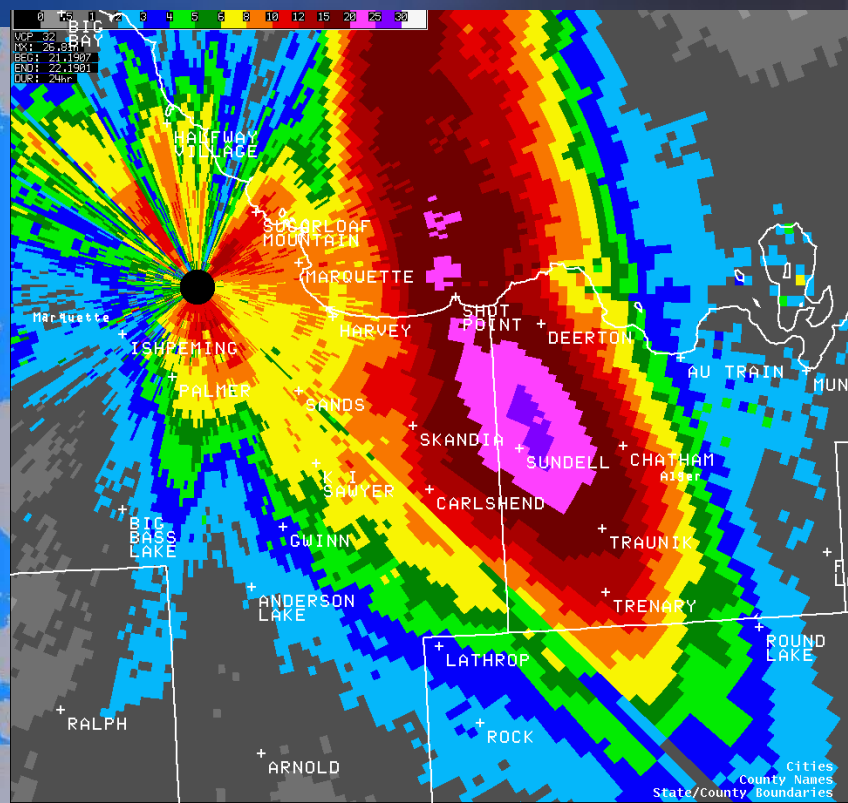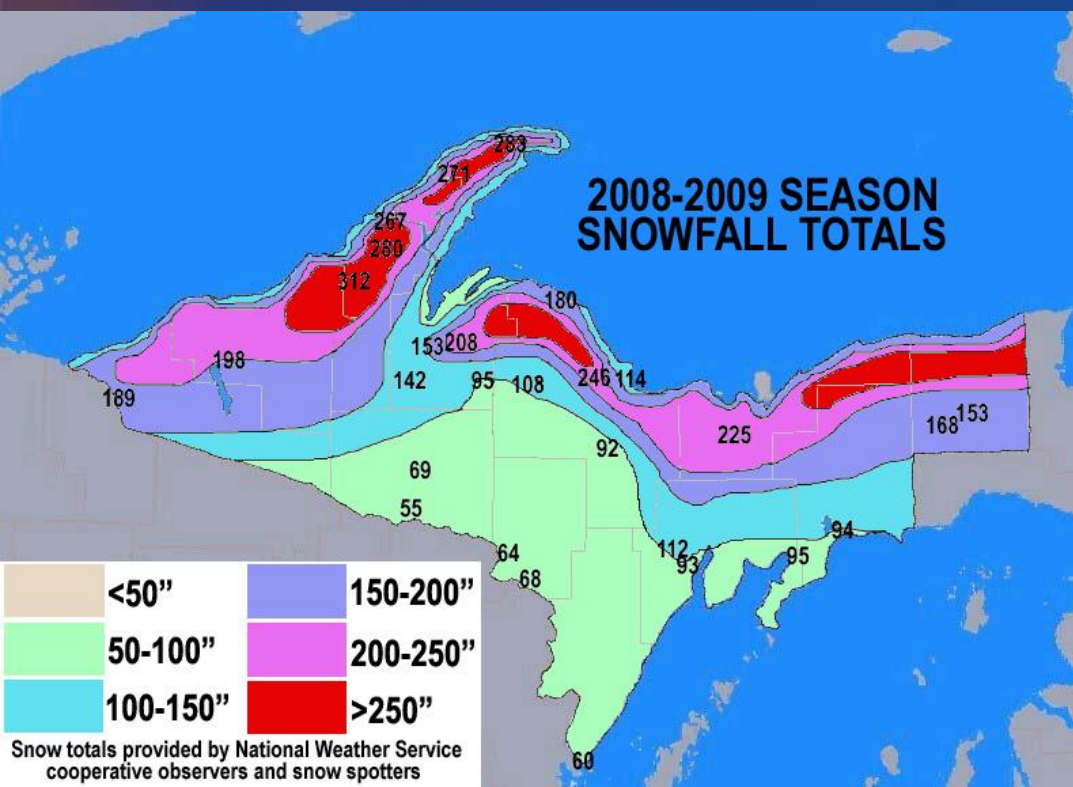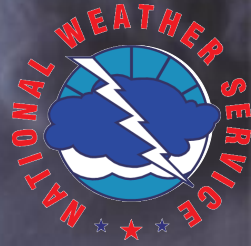
Preliminary Results

- **In the latest round of this research, we compared traffic incidents to several contributing factors. These include:**

  - *Snowfall Amounts*

  - *Time of Day*

  - *Day of Week*

  - *SLR*

  - *Wind Speeds*

  - *Temperature*

Number of Events (2007-2012)

Snowfall Range (in)	Number of events	Total Incidents
No Snow	2079	5449
T-0.5	1093	4379
0.5-1	230	1184
1-2	203	1528
2-4	160	1509
4-6	61	747
6-8	33	409
8-10	8	137
>=10	9	180
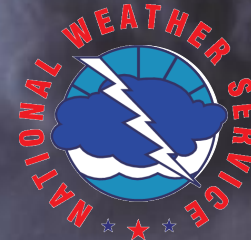
Day Vs. Night

- **Daytime periods had more incidents regardless of weather conditions**

Accidents/12hrs – Day Vs. Night
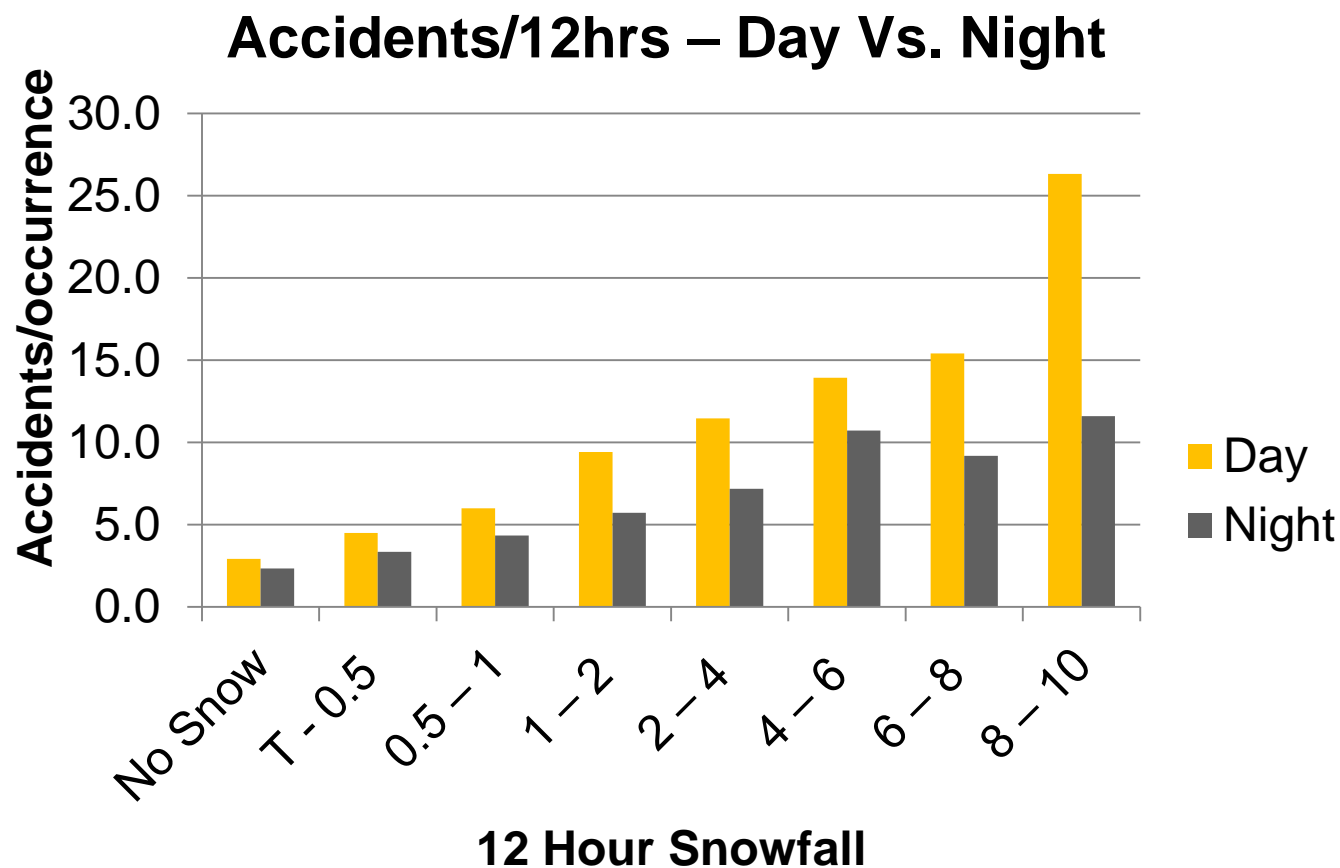
Time of Day

- **Late afternoons and early evenings had more incidents regardless of weather conditions**

Time of Day chart — Accidents/occurrence vs. 6 Hour Snowfall, by time period (00Z-06Z, 06Z-12Z, 12Z-18Z, 18Z-00Z)
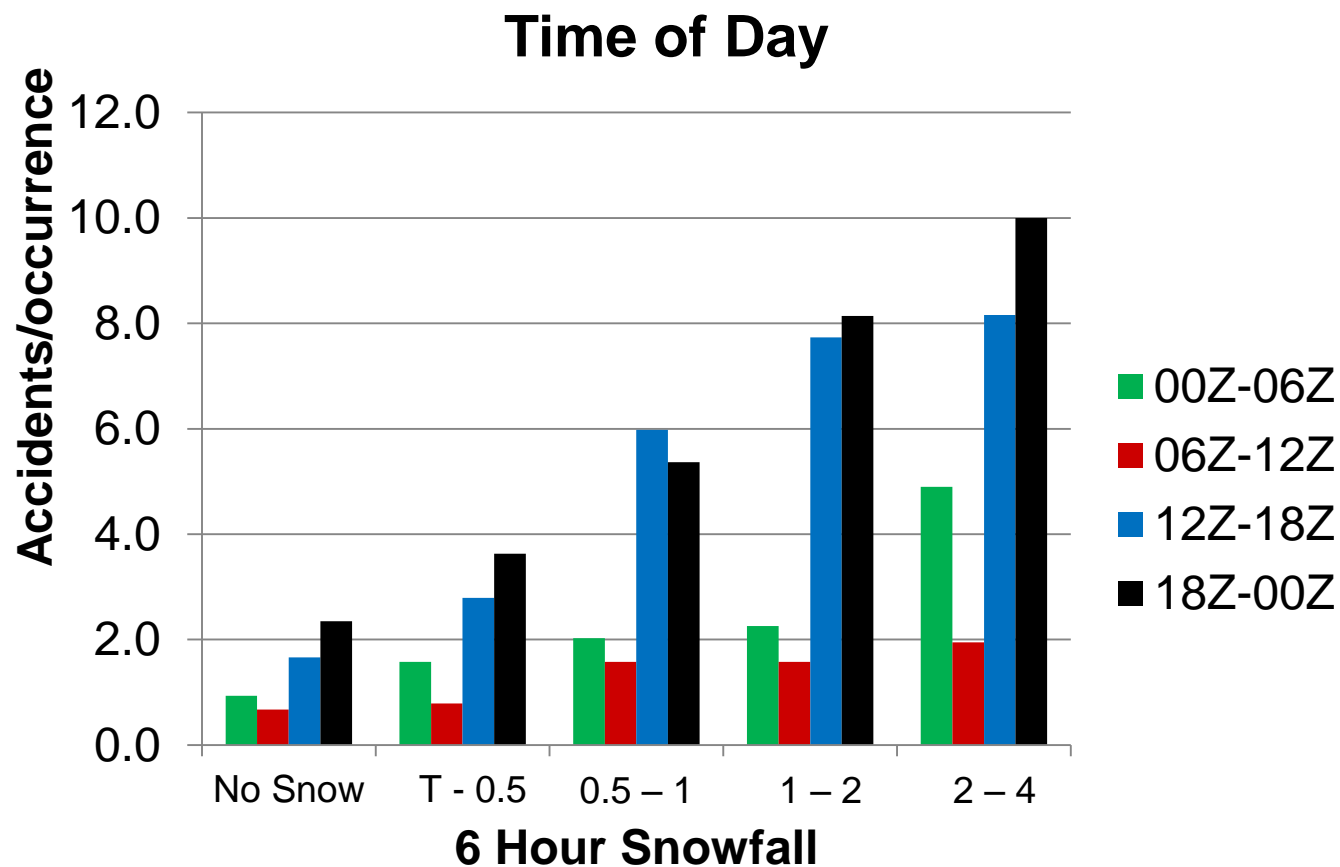
Low Vs. High SLR

- **Lower SLR values yielded higher incidents, especially values above 1 inch.**

Accidents/12hrs

Chart showing Accidents/occurrence vs 12 Hour Snowfall, with legend SLR<20 (green) and SLR≥20 (blue).
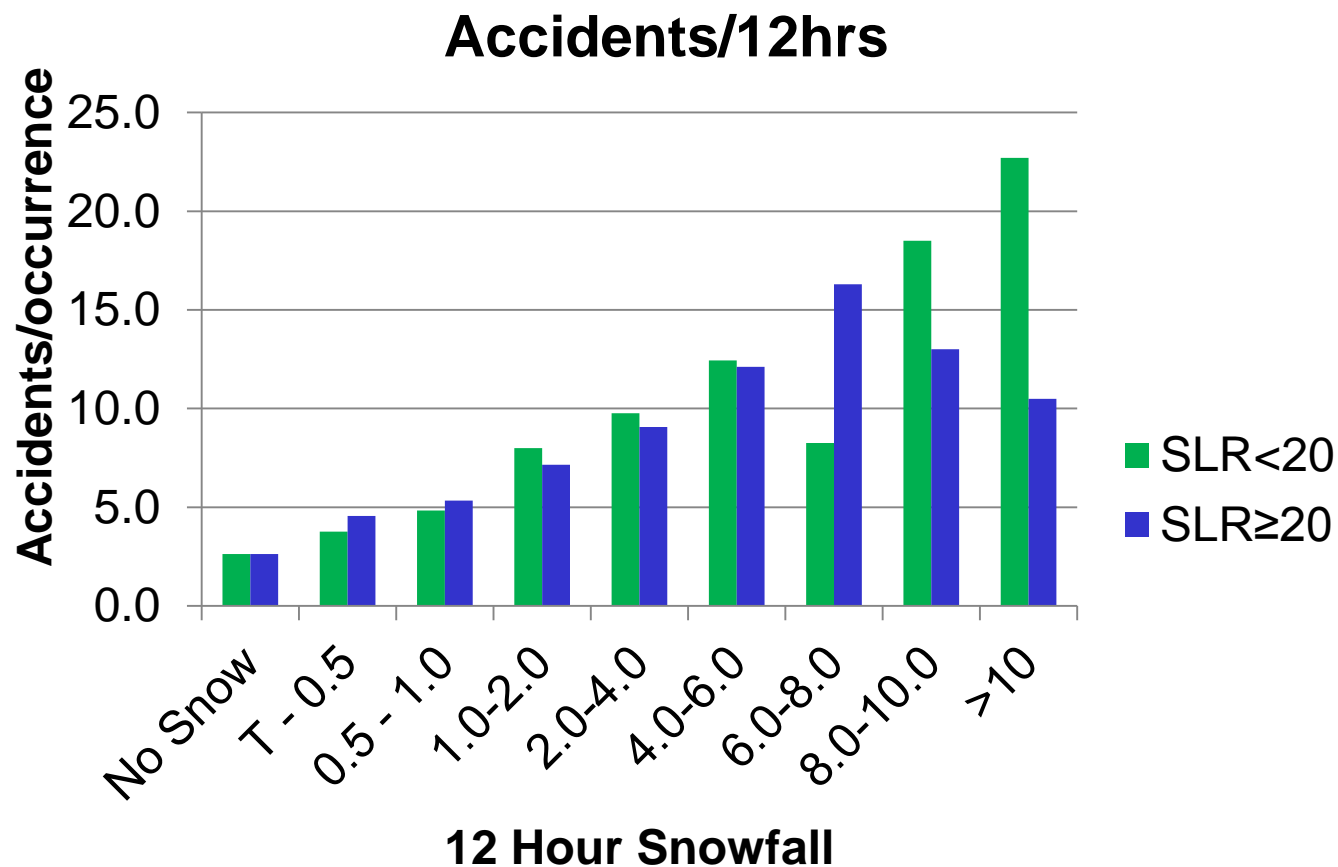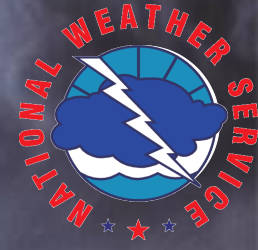
Low Vs. High SLR - Windy

- **Max Wind speeds >=15 kt counted**
- **High SLR combined with stronger winds generally yields more accidents**
  - *Blowing snow reduces visibility with more drifting*

Accidents/12hrs – Wind Speed >15 kt

Accidents/occurrence vs. 12 Hour Snowfall

12 Hour Snowfall	SLR<20	SLR≥20
No Snow	2.9	2.9
T - 0.5	3.8	4.6
0.5 - 1.0	5.2	6.0
1.0-2.0	8.4	7.5
2.0-4.0	10.0	10.3
4.0-6.0	12.0	13.2
6.0-8.0	9.2	16.3
8.0-10.0	18.5	
>10	22.7	16.0
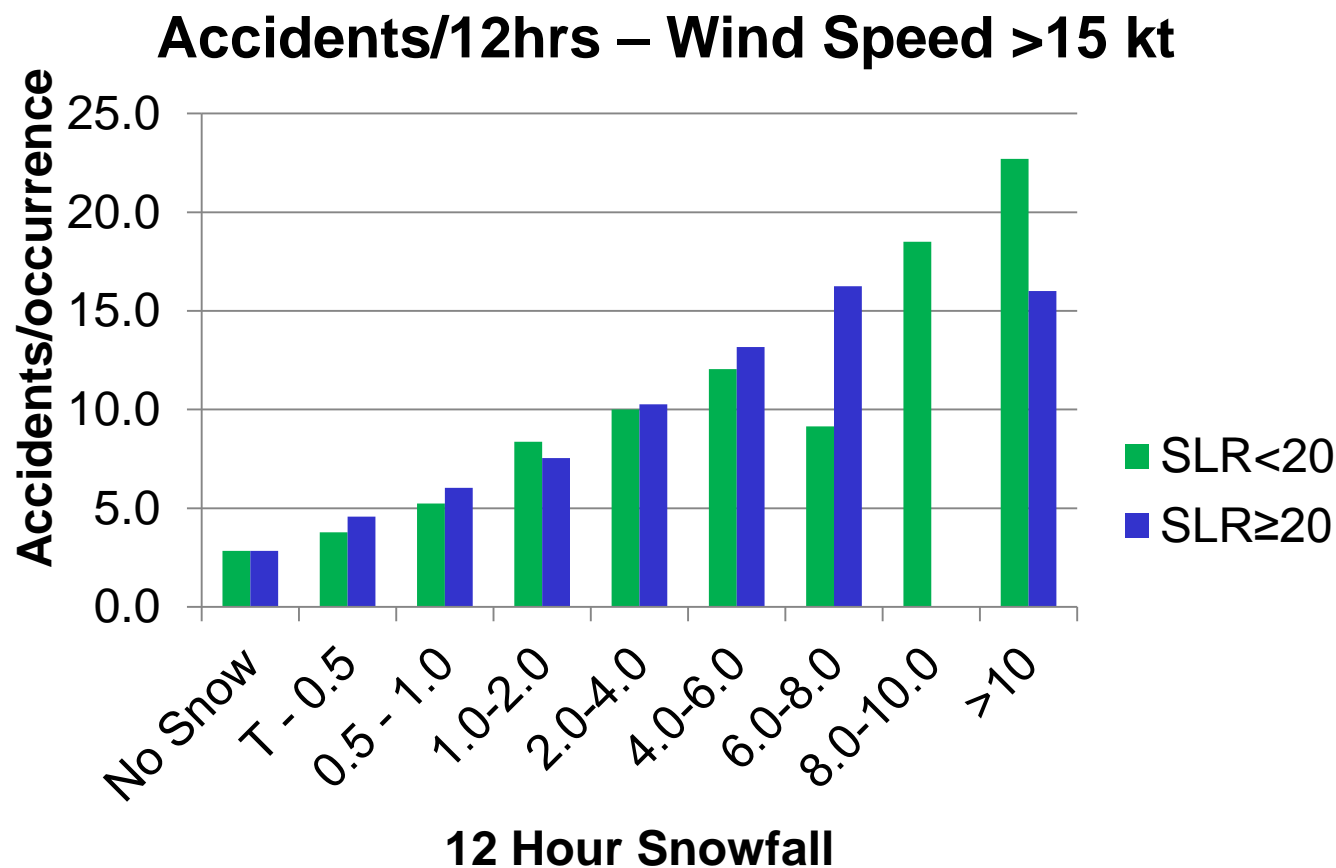
Low Vs. High SLR – Light Winds
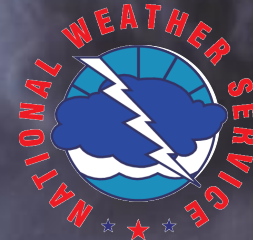
- **Wind speeds <15 kt counted**
- **Lower SLR values create more accidents during light winds, especially with higher snowfalls.**

Accidents/12hrs – Wind Speed <15 kt

Chart: Accidents/occurrence vs. 12 Hour Snowfall, comparing SLR<20 (green) and SLR≥20 (blue).
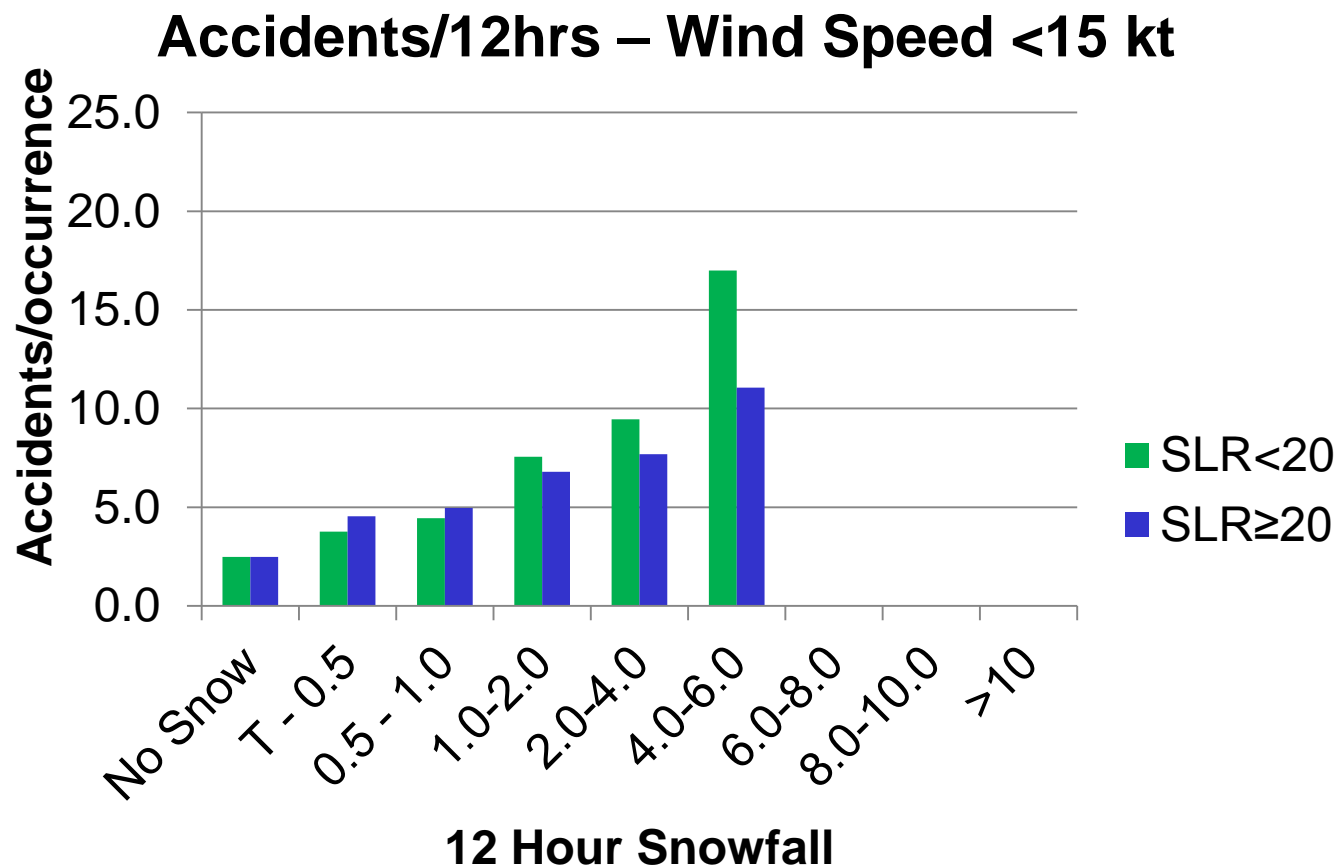
High SLR – Calm Vs. Windy

- **High SLR snow worse in windy conditions than calm conditions**

Accidents/12hrs – High SLR
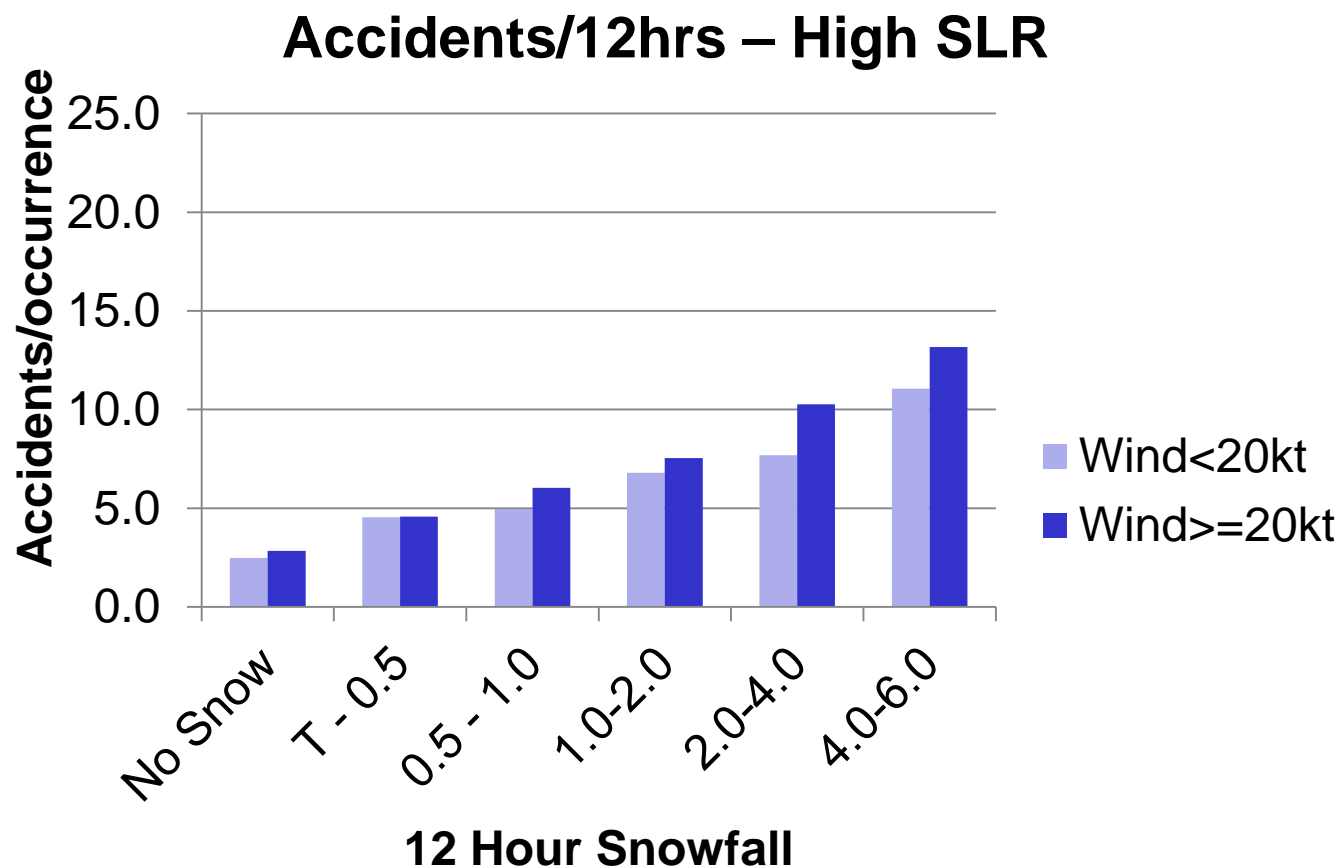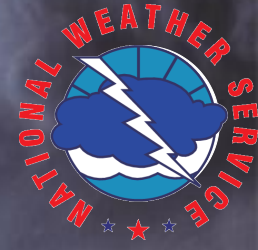
Low SLR – Calm Vs. Windy

- **Difference between windy and calm conditions more similar than with high SLR snow.**
  - *Low SLR snow is less prone to blow around*

Accidents/12hrs – Low SLR (<20:1)

Bar chart. X-axis: **12 Hour Snowfall** with categories: No Snow, T - 0.5, 0.5 - 1.0, 1.0-2.0, 2.0-4.0, 4.0-6.0. Y-axis: **Accidents/occurrence** from 0.0 to 12.0.

Legend: Wind<15kt (light green), Wind>20kt (dark green)

Snowfall	Wind<15kt	Wind>20kt
No Snow	1.8	2.0
T - 0.5	3.6	3.6
0.5 - 1.0	5.3	4.4
1.0-2.0	7.0	6.4
2.0-4.0	7.3	9.9
4.0-6.0	10.0	11.3
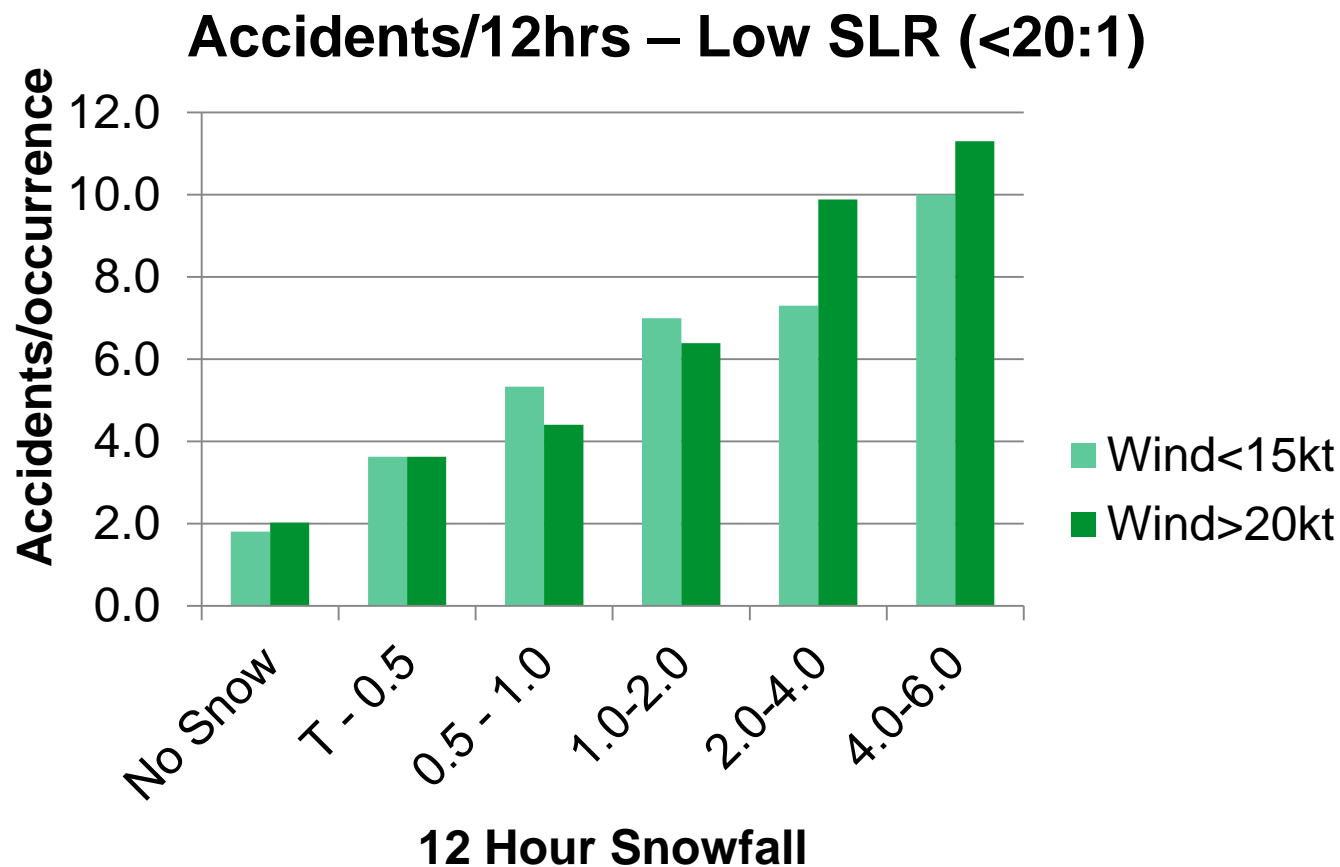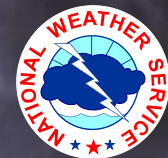
Snow vs. Temperature

Below 20F, road treatments are not as effective

Accidents/12hrs – All Snow

27 Nov 2007

Courtesy: The Mining Journal
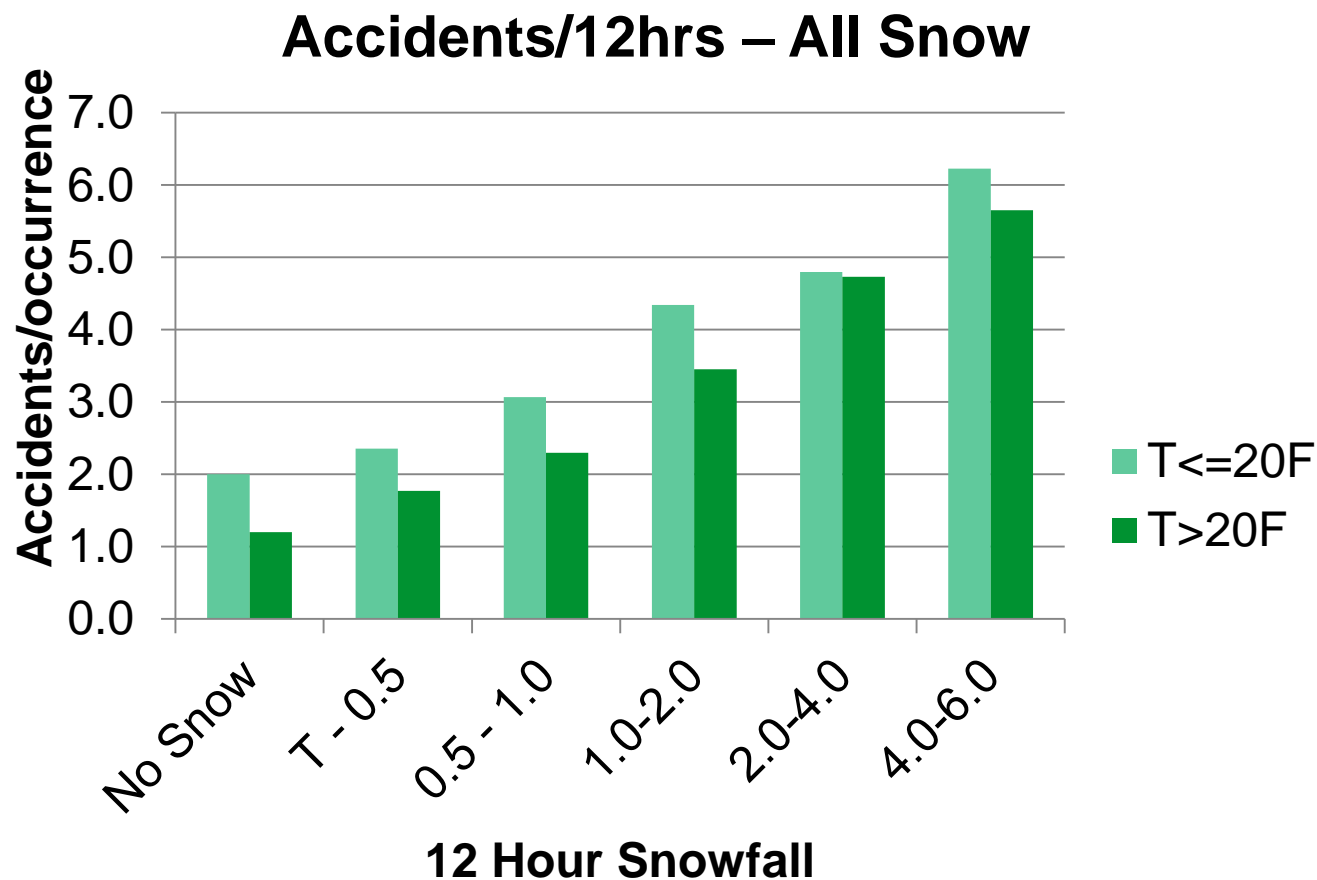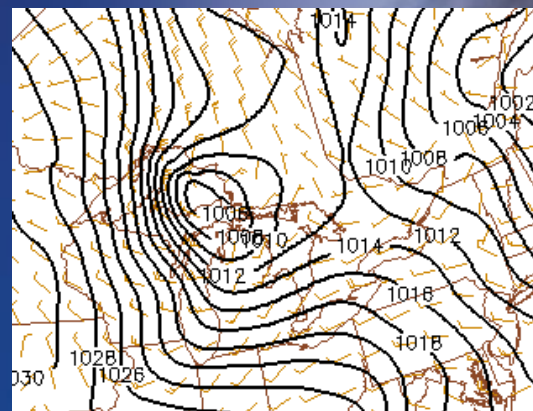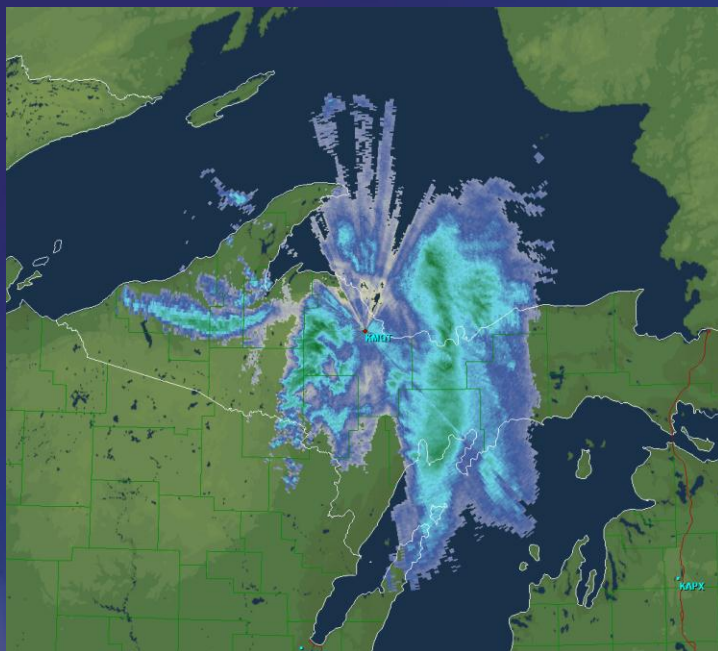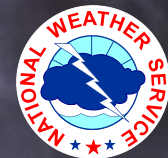
- Very intense, but short lived storm. Nearly 50 incidents were reported during the height of the storm (around morning commute - Tuesday)

- Storm total snowfall = 4.5 in

- SLR ~13:1

- Very intense sustained winds > 35 mph

- Frequent vsby < 1/4sm

- Duration of the main event (snowfall rates 1-2 in/hr) only lasted 2 hours (not blizzard criteria).

27 Nov 2007

2007 Dec 4-5

IEM NEXRAD Composite Base Reflectivity
Valid: 04 Dec 2007 13:00 UTC
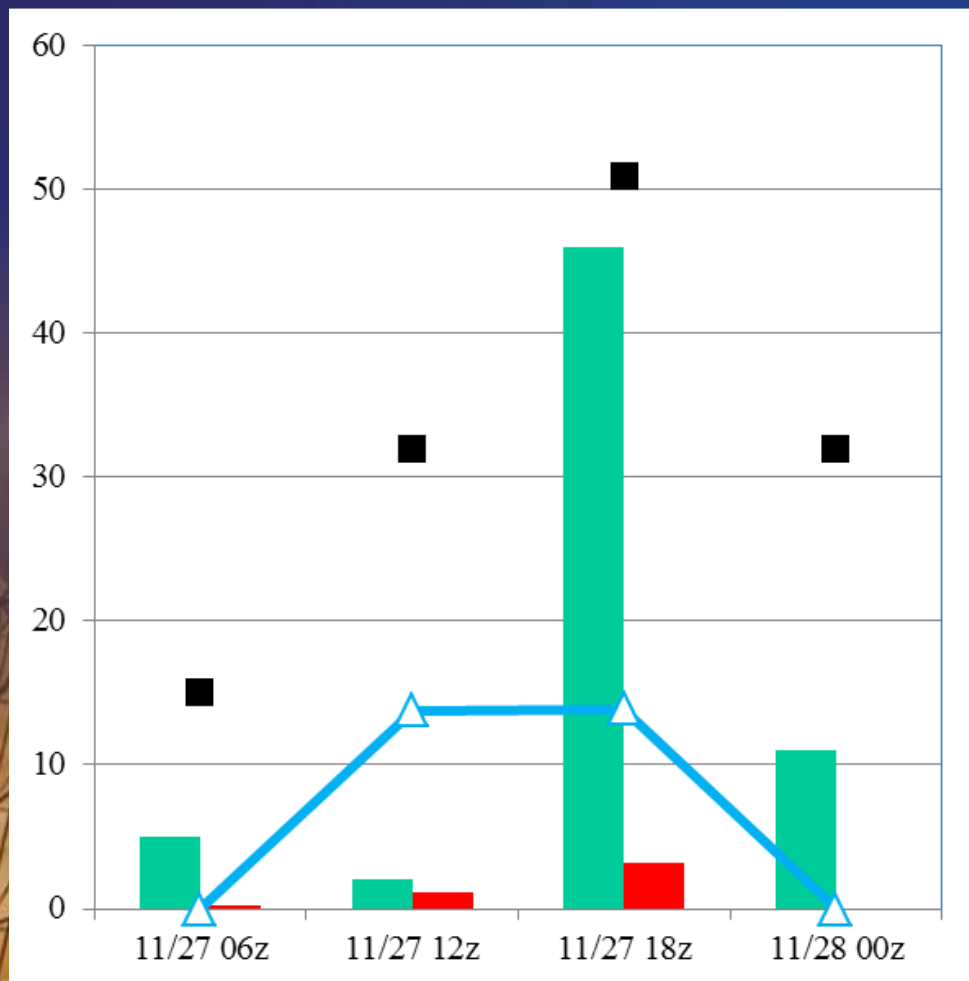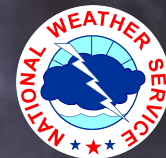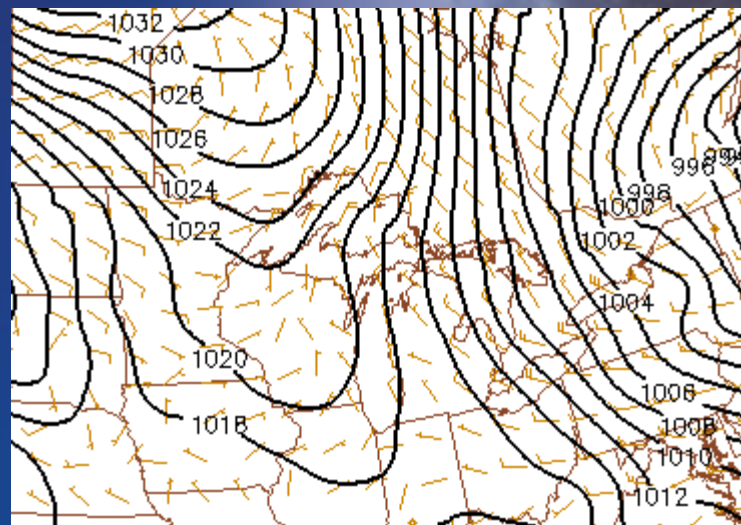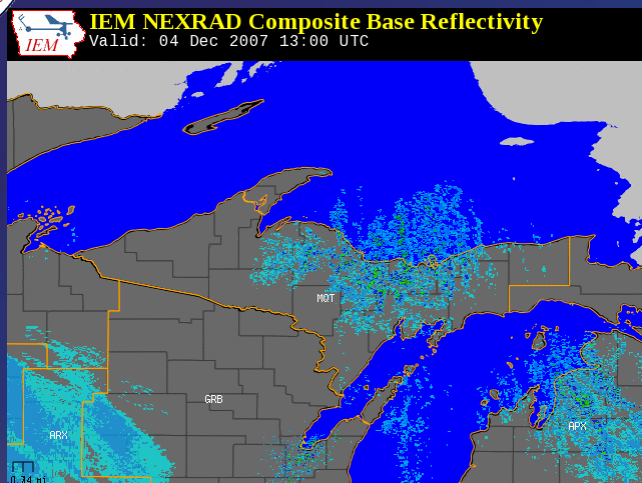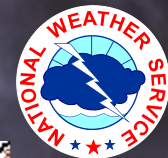
- **Classic long duration LES event – 10.3 in snowfall in 24hr (60hr snow of 2+ ft) during the week**

- **SLR ~ 32:1**
  - *Leaf Blower Snow*

- **Only 34 incidents in 24 hr**

- **Weak winds (<20kt)**
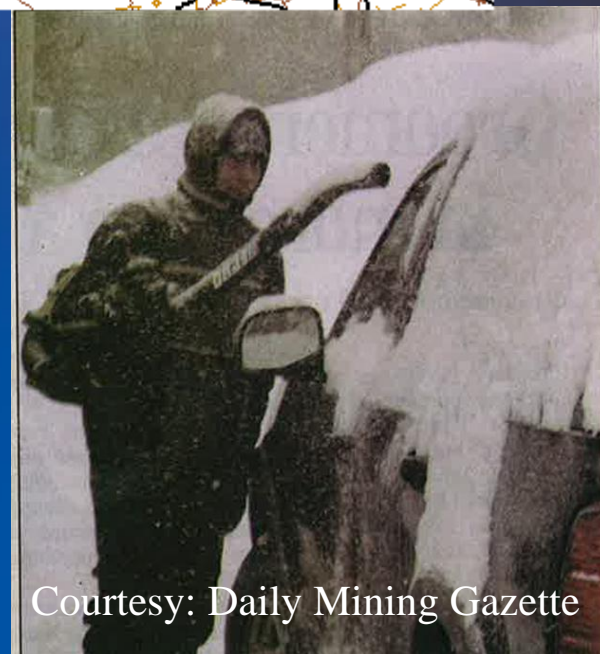
Courtesy: Daily Mining Gazette

2007 Dec 4-5
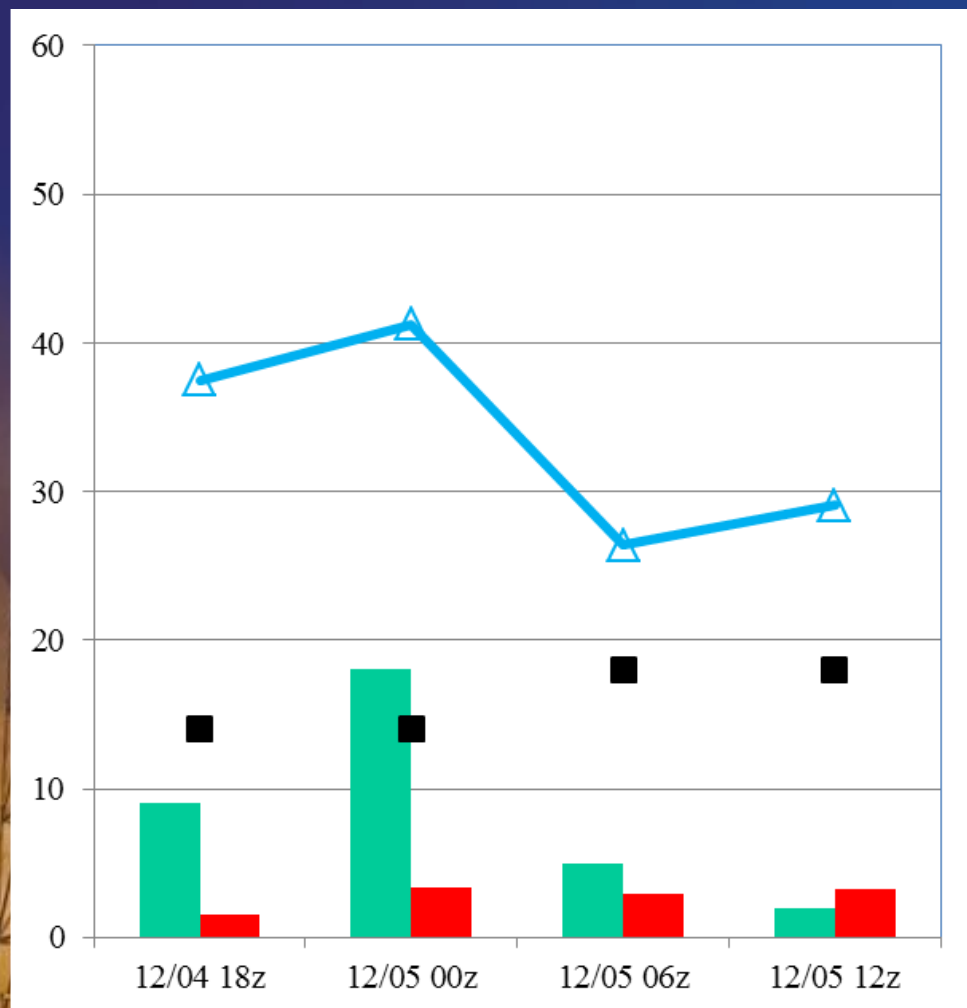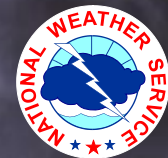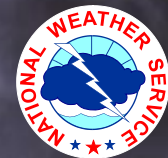
What these results have allowed us to do…

- **Refine our advisory/warning criteria:**

  – *8 inches for LES (>= 20:1 SLR)*

  – *6 inches for system snow (< 20:1 SLR)*

  – *We also give more forecaster discretion for "windier" events and/or issuing statements for critical time of day (commute times) or special events.*

- **Not place as dire impacts in our "standard" LES situations**

- **Focus more on the sub-advisory, high impact situations**

  – *Issue non-traditional statements for these events*

- **Develop new Decision Support type products based on impacts…**

Decision Support Activities for Winter Weather at NWS MQT

Why?

2007-2008 SEASON SNOWFALL TOTALS

<50"		150-200"	
50-100"		200-250"	
100-150"		>250"	

Snow totals provided by National Weather Service cooperative observers and snow spotters
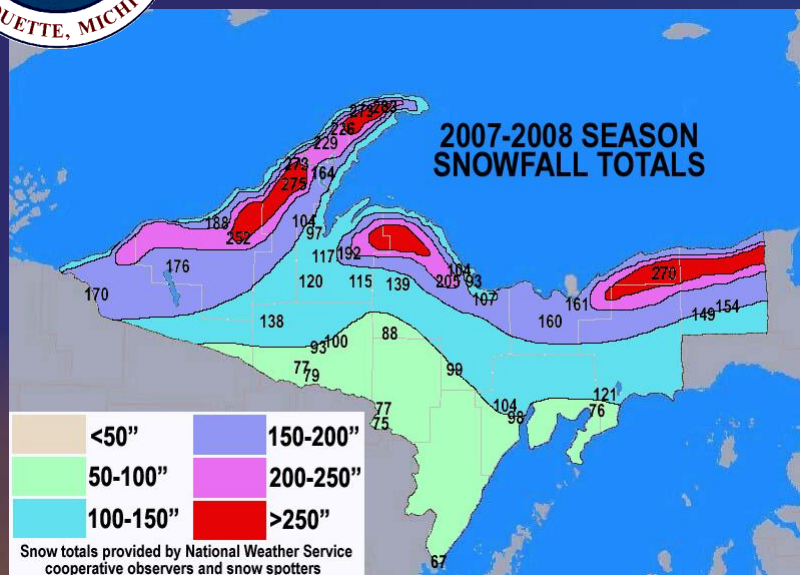
- **Some places in Upper Michigan see over 250 inches of snow each year**

  - *Amounts vary greatly from close to Lake Superior to well inland.*

- **Although the population of Upper Michigan is small (only +/- 500000 people), impacts from snow can still be significant (even with amounts less than our traditional warning criteria).**
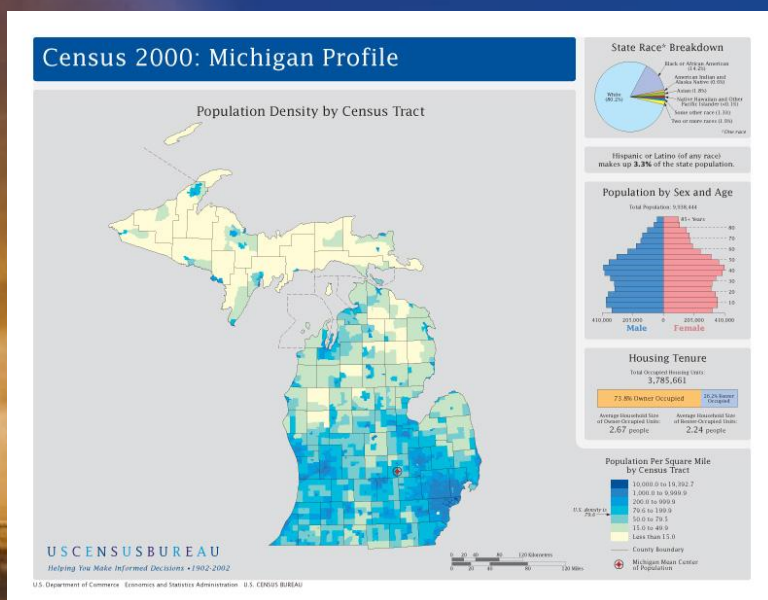
Primary Users of our Winter Forecasts

- **Public**

- **Transportation Sector (i.e. MIDOT, County Road Commissions)**

- **Schools**

- **Emergency Managers**

Our goal with Winter DSS

- **To provide the best information for decision making using technology by leveraging our digital forecast database.**

- **We also want to give our customers detail on exactly where the worst conditions will occur**

- **For high impact events, we also use more traditional type of DSS including:**

  - *Conference Calls*

  - *Webinars*

  - *Phone-Phone contacts*

Winter Hazards Page

- **This page allows us to package all of the winter hazards into a temporal series of images (6 hourly)**
- **It allows our users to quickly see what winter hazards will affect them without having to sort through a long forecast**
- **Differentiates between "types" of snow as well as the main hazards based on our winter impact experiment**

Derived from our Digital Forecast

Winter Hazards Page

Lake Effect Snow Example

Can be very specific regarding where the worst conditions will occur.
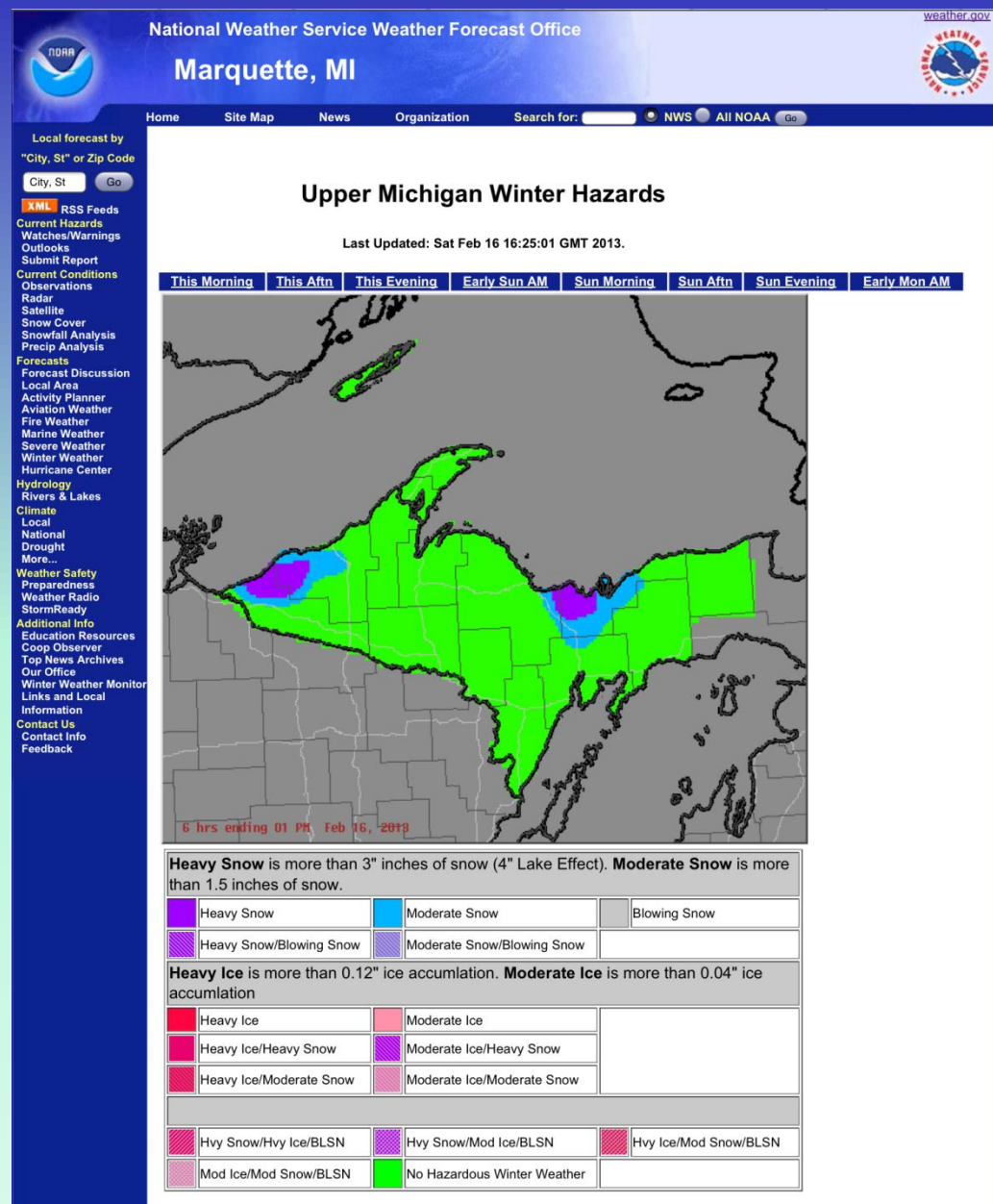
Probabilistic Snowfall

- **Based on PQPF work done by Steve Amburn (NWS Tulsa) and PSNOW work by Dr. Greg Mann (NWS Detroit/Pontiac)**

- **Derived from PoP and Quantitative SnowAmt forecasts**

  - *Allows us to give an unconditional probability to exceed specified snowfall amounts*

- **Based on the climatological distribution of precipitation, which very closely matches the special gamma distribution called the exponential distribution (results similar to Jorgensen, Klein and Roberts, 1969)**

  - *Indicates that the probability of receiving larger rainfall/snowfall amounts decreases exponentially as amounts get larger*

- **Allows us to quickly give customers our confidence on critical snowfall thresholds as well as our likely range of values**

See **http://www.crh.noaa.gov/mqt/?n=pqpf_explain** for more details

Probabilistic Snowfall
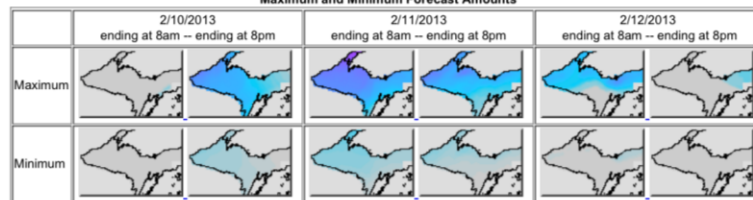
Thanks to NWS Detroit for much of the software
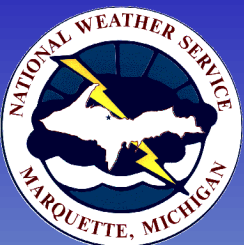
Winter Monitor Page

One stop shop for all of our winter products

Where we send everyone too for winter information

Also links to other outside pages
- • **Webcams**
- • **DOT Road Conditions**
- • **WPC products**

Enhanced Hazardous Weather Outlook (EHWO)

- **A graphical way to look at a complete suite of weather and water hazards across Upper Michigan (including winter hazards)**

- **Developed by NWS Springfield Missouri.**

- **Totally derived from our gridded forecast database (although manual intervention is also necessary at times)**

- **Daily resolution out to 7 days**

Experimental

Enhanced Hazardous Weather Outlook - Maximum Risk for Each Day (click link or hazard icon to enter site)

Today/Tonight						Max. Risk Days 2 to 7 (All Hazards)					
Severe Thunderstorms	Flooding	Winter Weather	Fire Weather	Other Hazards		Sat Apr 27	Sun Apr 28	Mon Apr 29	Tue Apr 30	Wed May 1	Thu May 2
🟩	🟩	🟩	🟩	🟨	Land	🟧	🟧	🟧	🟧	🟧	🟧
					Marine	🟨	🟧	🟨	🟧	🟩	🟩

Example EHWO for LES

Thank You

Questions?

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